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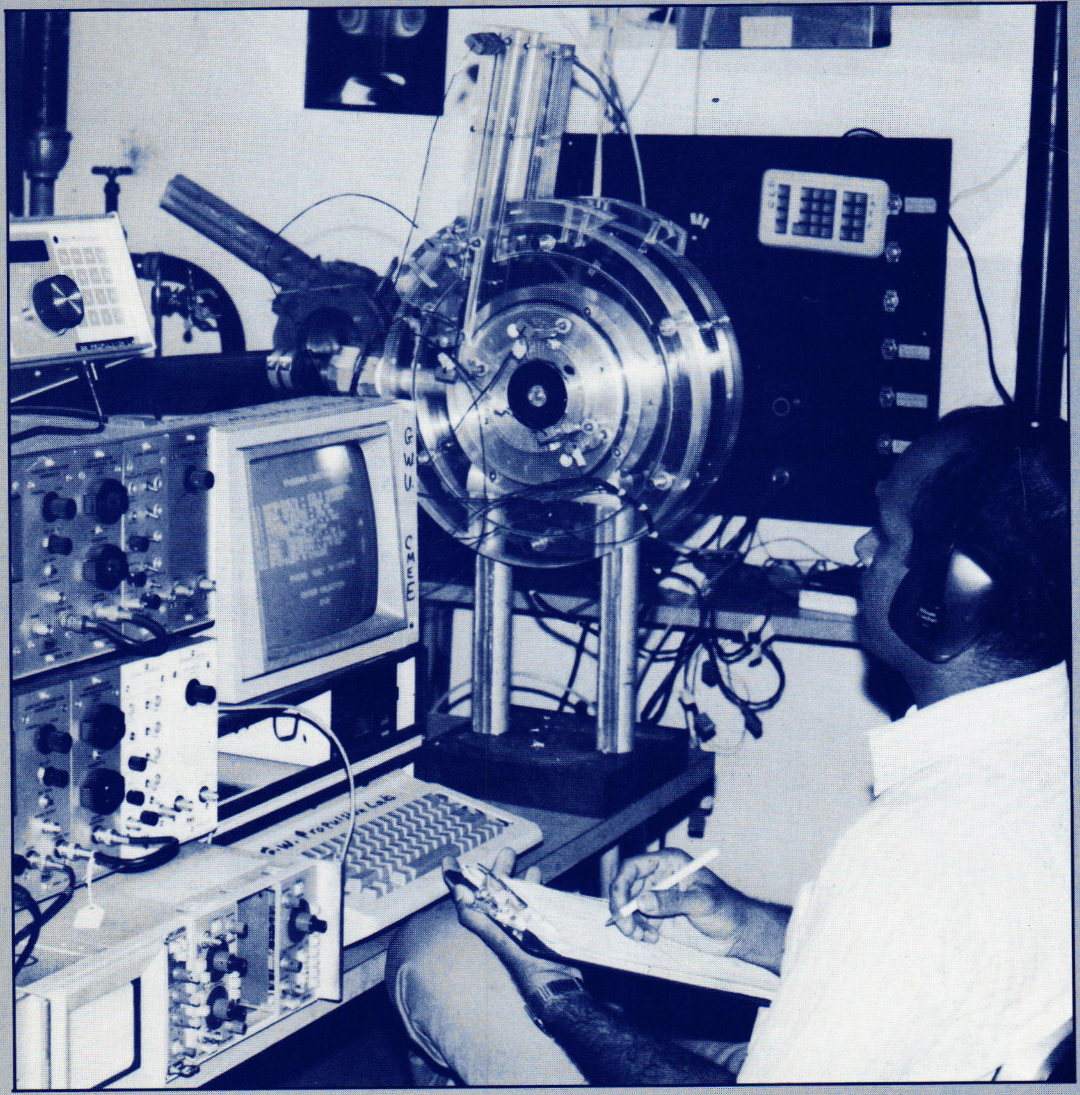

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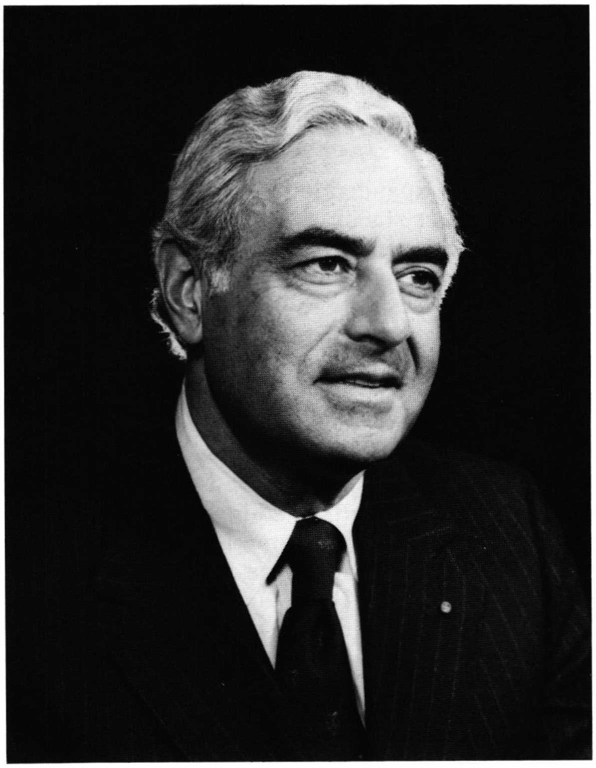
Established 1942

COVER: The Foa Energy Separator is a new device that can be used in heating and air conditioning the cabins of airplanes, and electronic devices. This device could be very effective for cooling the bodies of very high speed jet planes.

Departments

LETTER FROM THE DEAN



I am pleased to share with you news on recent events at the School of Engineering and Applied Science as we continually strive to keep our programs at the forefront of engineering education. During a decade of rapid economic expansion and exponential growth in high technology, the School has kept pace with these advances by providing high quality education to meet the challenges of today's changing world. A rapidly changing profession requires education for the future based on fundamental principles of science applicable to a dynamic, advanced society. In the fields of engineering and applied science, there is no substitute for demonstrated competence; without question, achievement in particular courses of study is important. Equally important, however, is the ability to analyze all aspects of a problem, to formulate solutions and to evaluate those solutions in light of all available information.

In an effort to assure competence in future engineers, the School continues to enroll highly qualified undergraduate students each year. The academic profile of our entering classes continues to be the highest of the University's freshmen class each year. In 1986, the mean SAT scores of entering SEAS students were 550 verbal and 640 mathematics with 45% of the incoming freshmen ranking in the top 10% of their high school classes. In comparison, the mean SAT scores of all new students who enrolled in SEAS this Fall are 550 verbal and 660 mathematics.

SEAS recently was awarded a grant from the Department of Defense to administer a Science and Engineering Apprentice Program, which provides opportunities for academically qualified high school students with interests in science and mathematics to serve as apprentices to science and engineer mentors during an eight week summer period at Washington-area government laboratories. The students gain insight into the engineering and scientific environment as a first step in making educational and vocational career decisions. Applications for apprenticeship positions were received from approximately 2,000 students; 560 of these applicants were accepted into the program. In addition, students selected to participate in the apprenticeship program and several hundred non-senior high school applicants not given laboratory assignments were invited to apply for one of two freshmen engineering courses; namely, "Introduction to Computing" and "Engineering Drawing and Computer Graphics". These letters of invitation resulted in 200 applications of which one-half were selected for the courses. Students who enrolled in the classes are extremely bright and talented individuals, with probably all of them college bound. The average Scholastic Aptitude Test scores for these students may be applied toward degree requirements at the School of Engineering and Applied Science or at another institution of higher education. This is only one of a number of programs to encourage achievement in engineering education. The Engineering Honor Scholarship Program also attract academically gifted students. These scholarships, based on academic merit, are awarded at the end of the secondary school junior year or to undergraduate transfer students and consists of full- and half- tuition awards dependent on academic standing. Nineteen new students accepted Engineering Honor Scholarships for th 1987-88 academic year.

SEAS continues to earn distinction for the high standards of the academic and research activities in disciplines of engineering and applied acience. Undergraduate programs in Civil Engineering, Computer Science, Electrical Engineering, Mechanical Engineering, and Systems Analysis and

Engineering have expanded in offerings and supporting laboratory facilities. All of the undergraduate engineering programs are accreditated by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (EAC/EABET). During the past year, undergraduate programs in electrical engineering and the computer engineering option of electrical engineering were reviewed by ABET and the electrical engineering program was re-accredited and the computer engineering option of electrical engineering was accredited. In addition, the computer science undergraduate degree program became one of only forty-eight four-year degree programs in the United States to receive accreditaiton by the Computer Science Accreditation Commission of the Computing Sciences Accreditation Board (CSAC/CSAB).

Also, the School's graduate degree programs have met expanding demands with instruction and research in over forty-five areas of specialized study. These opportunities are enhanced by the advanced research conducted at eight internationally recognized research institutes, including the Institute for Technology and Strategic Research (ITSR), which was established this year with Dr. Edward Teller as its Honorary Director and Co-Founder. Examples of research areas for ITSR include: Missile and Space Launch Controls and Progress in Superconductivity. In addition, a cooperative agreement was executed with Louisiana State University to form the Joint Ports and Waterways Institute. This Institute will serve to enhance the education and training programs and opportunities for maritime professionals.

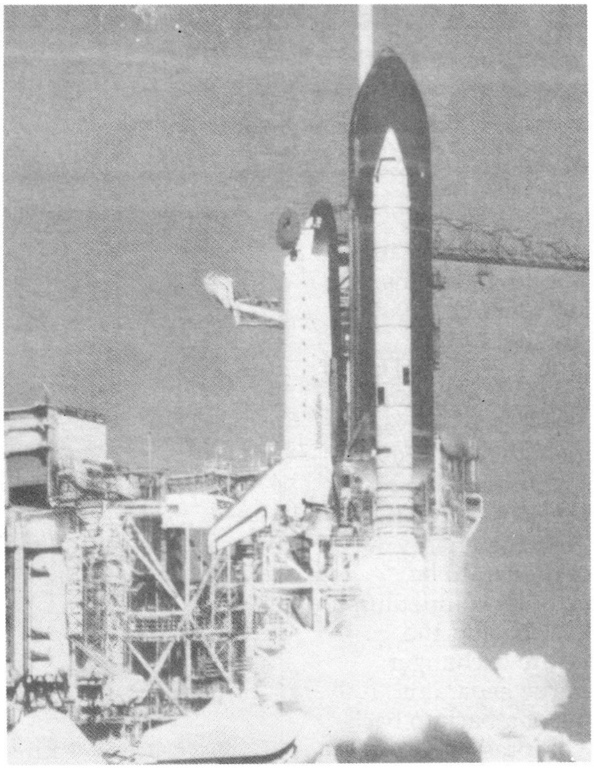
The Continuing Engineering Education Program provides non-credit courses worldwide to professional engineers in an effort to keep them abreast of changes in technology. This year, CEEP offered 502 courses to 14,253 professionals in engineering and supporting fields. In cooperation with the GWU television system, CEEP is now able to broadcast seminars and courses via a satellite down-link system. Recent courses taught by Dr. W. Edwards Deming and Dr. Peter F. Drucker were highly successful when broadcast through the satellite down-link system. In addition, video tapes of each broadcast are recorded and available for distribution to interested groups and individuals. These activities of CEEP provide opportunities for advanced study, training, and contribute to the School's involvement with industry.

The School of Engineering and Applied Science is actively taking part in more cooperative research efforts bridging the resources of government and industry, most visibly in our exciting plans for The GWU Northern Virginia Campus. The Northern Virginia Campus will serve as a center for engineers and scientists to pursue their research. This new facility will serve the continual needs of industry and strengthen the industry-university linkage by providing a unique opportunity for scientists, engineers, and students for study and reseach. A major focus will be on strengthening engineering and technology in the United States, with particular emphasis on educating and training students for research and fostering technology transfer to industrial applications.

The SEAS Advisory Council believes that this is a most exciting, and perhaps unique opportunity to thrust the School of Engineering and Applied Science and the GWU to a position of recognized eminence among the leading national academic institutions. Continuing close relations with industrial organizations that are active in engineering and applied science research will serve to facilitate academic excellence.

The School of Engineering and Applied Science is committed to moving forward and continuing to raise the high quality of undergraduate, graduate and professional programs, increasing sponsored research programs, and providing state-of-the-art facilities to support the word of faculty and students. The ongoing commitment and continuing dedication and effort of our students, faculty, alumni, and friends will enable us to meet the challenges of a changing world with well-educated engineers and scientists, thus increasing our academic excellence and our service to mankind. The School of Engineering and Applied Science is committed to the mission of being a center of academic and research excellence.

Harold Liebowitz
Dean



NASA

The shuttle, Discovery, blasts off toward the final frontier in its first mission.

NASA Gets a Boost Toward Space

On January 28, 1986, the nation was shocked by the news of the explosion of the space shuttle, Challenger. The space flight was terminated just seventy-three seconds into the launch, when the Challenger was totally destroyed.

An extensive investigation followed this major NASA setback, and it was discovered that the shuttle explosion was due to defective boosters which were used in the construction of the space shuttle. Future NASA space flights were cancelled, and it was speculated that the shuttle program was uncertain. Now, new life has been breathed into the shuttle program.

In early September, Morton Thiokol successfully fixed the booster, which was redesigned for use in NASA's shuttle fleet. When the desert outside Brigham City, Utah, was transformed into fire and smoke, it signaled the beginning of a new era for NASA. The first major technical hurdle in the path of the shuttle program has been cleared and the resumption of flights is set for next summer.

Engineers from Morton Thiokol are now doing post-launch tests to look for charring or erosion on the booster joints. Any such occurrence would be an indication of the leakage of burning gasses which led to the destruction of the Challenger.

There are still more rigorous tests which have to be passed by the booster, but as of now, officials of NASA and Morton Thiokol are happy with the progress. "We waited a long time to see this," says Richard Truly, NASA Associate Administrator.

— *Joy Rogers*

The Mysterious Planet X - Is It Out There?

Our solar system contains 9 known planets, the last three of which are Neptune, Uranus, and Pluto. Yet, could there be a massive Planet X, yet undiscovered, which lurks in the shadows beyond Pluto? Many astronomers certainly think so.

Observations of Uranus since it was discovered in 1781 show that something is pulling on the planet, thus, disturbing its orbit. When Pluto was discovered in 1930, many astronomers felt that they had finally found the culprit, but Pluto proved too small to cause such large perturbations in Uranus' orbit. In fact, Neptune has since been found to have perturbations in its orbit as well.

John Anderson at the NASA Jet Propulsion Laboratory, is in charge of monitoring the gravitational effects on the Pioneer 10 and Pioneer 11 spacecrafts which are now heading out of the galaxy in opposite directions. After five years of faithful observations, Anderson has been given food for thought. He has found that nothing, absolutely nothing, other that the known planets, is exerting a gravitational pull on the spacecrafts.

Curiously, this is what convinces Anderson that there truly exists a tenth planet. "The most straightforward explanation," he says, "would be that there is nothing there." Then, this would mean that all the historical measurements of orbital perturbations were wrong. This, to Anderson, is impossible since Astronomy - is a precise science which was already quite advanced in the 1880s.

In actuality, Uranus wobbles so much in its orbit, that Anderson

Continued on page 17

FOA ENERGY SEPARATOR: A New Method of Heating and Air Conditioning.

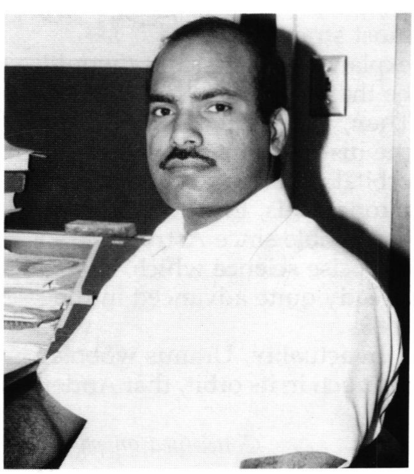
by M. Ilyas Anjum

The Foa energy separator is a unique invention that provides a very useful demonstration of the law of conservation of energy. With the invention of this device, another member has been added into the family of heating and air conditioning systems. In the propulsion research laboratory, situated in the basement of the Tompkins Hall of the School of Engineering and Applied Sciences, one can see the working model of Foa energy separator. In a study made by Prof. C.A. Garris of the CMEE department, the Foa energy separator has proven to be superior to all of its competitors i.e. the vortex tube and the dynamic pressure exchanger.

The Foa energy separator, which consists of a back to back turbine and compressor arrangement, is a device in which an initially homogeneous flow is split into two subflows and the energy level of one flow is increased at the expense of the other. The two outputs may be used either jointly or separately in the heating and cooling units. In addition to its applications in heating and air conditioning the building, this device can also be used in jet propulsion systems, where the cold air can be used for cabin cooling and the hot air can be utilized for thrust augmentation purposes. In all of the air conditioning and heating devices, the compressor and turbine are placed in series. However, in the history of heating and air conditioning systems, this device is one of a kind because it's components, compressor and turbine,are placed in parallel. This means the air flow passes through both of them, simultaneously.

So far two types of energy separators have been described in the literature; an internal and an external energy separator. Both types use the same principle of cryptosteady energy transfer which provides an efficient mode of energy conversion through the non-dissipative work of pressure forces. In the case of internal energy separator, transfer of energy takes place inside the rotating member whereas for the case of external energy separator, energy is transferred outside the rotor. The available literature on the turbo machinery proves that the radial flow vanes with back

Mohammed Ilyas Anjum is a doctoral candidate in the Mechanical Engineering Department. His dissertation topic is "Flow Transients in the Vaneless Diffuser of Foa Energy Separator". His area of specialization is fluid mechanics and thermal science. He got a 3 year diploma of Associate Engineering in Mechanical Technology from Polytechnic Institute, Lahore,Pakistan. Bachelor of Science in Mechanical Engineering in 1982 from University of Engineering and Technology, Lahore,Pakistan,and Mastor of Science in Fluid Mechanics and Thermal Science from GWU in 1984. He has been working with the propulsion research group for the last five years. The model of Foa internal energy separator shown in fig 1. has been designed, prepared and tested by Mohammed Anjum.



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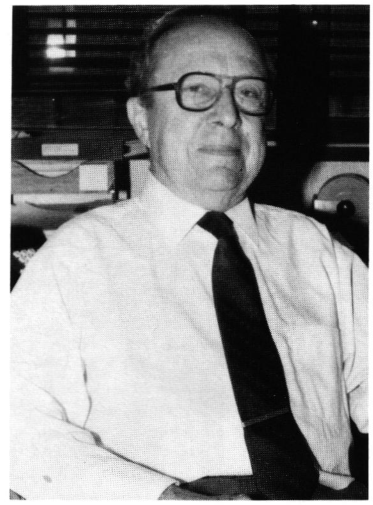

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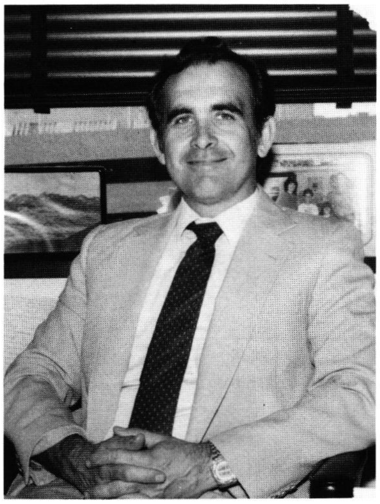
Professor Joseph V. Foa is a Professor of Emeritus in the School of Engineering and Applied Science. Professor Foa got his Doctorate of Mechanical Engineering from Politecnico di Torino (Italy) and Doctorate of Aeronautical engineering fomr the University of Rome. He has many years experience working with aircraft companies and universities. He is an expert in the area of propulsion. The Foa energy separator was patented under his name when he was a professor at RPI. He has been involved in extensive research programs throughout his teaching profession. The work discussed in this article is being done under his quidance.



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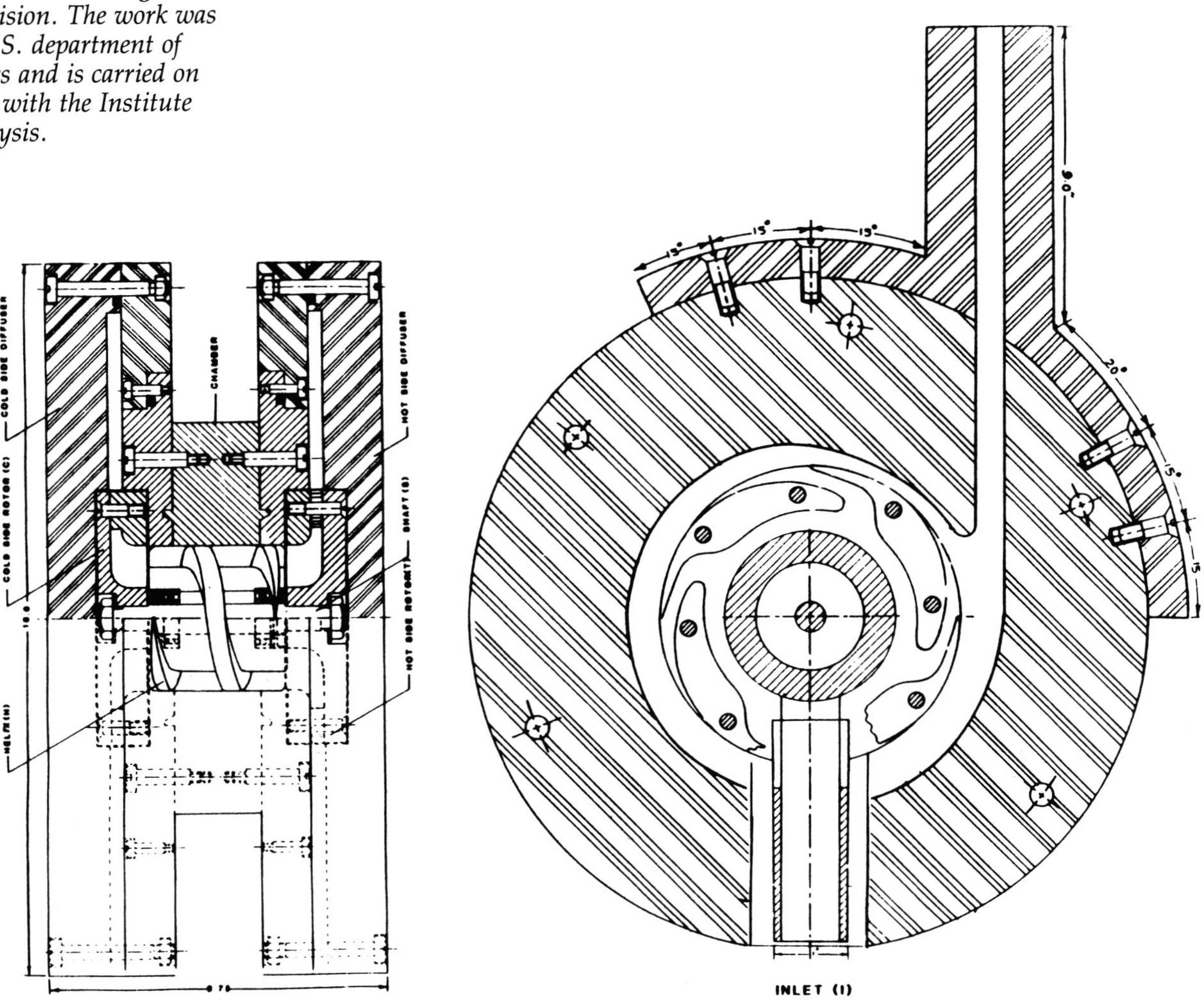
Professor Charles A. Garris is the chairman of the propulsion research group. He is a full time faculty member of the CMEE department. He got his PhD in Fluid Mechanics and Heat Transfer from the State University of New York. Professor Garris has been involved in many activities related to propulsion research. The experimental work presented in the article is being done under his supervision. The work was funded by the U.S. department of energy for 3 years and is carried on under a contract with the Institute for Defense Analysis.

swept angle minimize the energy losses and improve the energy transfer and flow collection arrangement of turbines and compressors. A recent study by Prof. J.V. Foa and L. Xie of the CMEE department shows the features of an energy separator with radially discharged vanes.

Under the contract of the U.S. department of energy, and experimental program was undertaken in support of designing, fabricating and testing this particular type of Foa internal energy separator that has radially discharged vanes. Like the other models of energy separator, this model has the same working principle and the similar components. As shown in fig(1), the compressed air enters at (I), then it is passed through the helical fence(H) which divides the flow into two parts. One part of the air enters into the turbine(T) and the other part is directed into the compressor(C) which is mounted on the same shaft(S). Due to an appropriate design of the turbine nozzles, the air leaving the turbine at E provides a certain amount of work which is transmitted to the air passing through the compressor nozzles. By doing so, the air leaving the turbine loses energy and becomes cooler than the inlet air and the air leaving the compressor gains energy and becomes hotter than the incoming air. As a result, the energy separator provides a very useful demonstration of the second law of thermodynamics. The cold flow can be used for air conditioning purposes and the hot flow can be utilized for heating purposes.

Fig 1. Foa Internal Energy Separator mode 3C-IV.



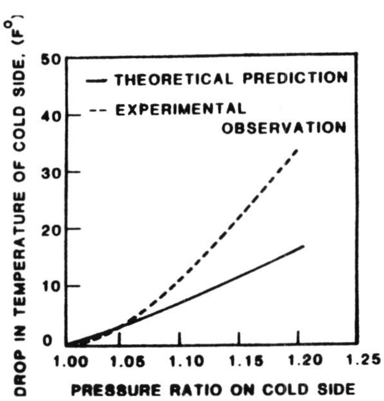


Fig 2a. Comparison of temperature drop on cold side vs. pressure ratio.

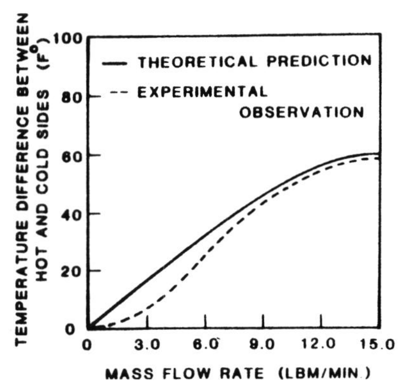


Fig 2c. Comparison of overall temperature difference between two sides vs. mass flow rate.

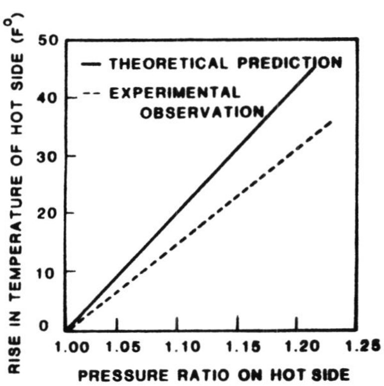


Fig 2b. Comparison of temperature rise on hot side vs. pressure ratio.

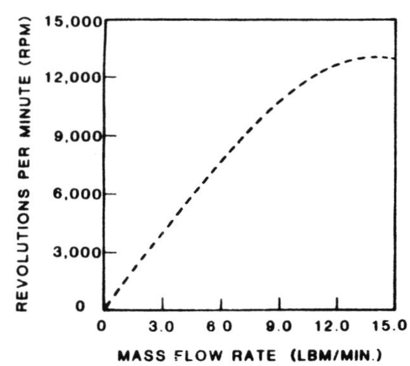


Fig 2d. Graph of experimental values of rpm vs. mass flow rate.

Depending upon the requirement, the heating and cooling capacity of the device can be controlled by various parameters. A few of them are: area ratio(the ratio of the total area of the hot side nozzles to the total area of the cold side), the pressure ratio(the ratio of pressure of air at the entrance to the exit) and the nozzle angles. This particular model has four nozzles of the cold side and two nozzles on the hot side, providing an overall area ratio of 0.24. The nozzle angles for cold and hot side nozzles are 15 and 7.5 degrees, respectively.

Using the most modern flow measuring instruments, the model has been tested. The results show that the performance of the mode is highly encouraging. So far the tests have been limited to 15,000 rpm at a pressure ratio of 1.2. However, plans are undertaken to increase the rotational speed of the device by increasing the pressure ratio. Fig.(2a) shows the graph of drop in temperature, meaning the difference between the temperature of air at the entrance of the energy separator to the exit on the cold side, versus the pressure ratio on the cold side. Similarly, Fig.(2b) shows a graph of rise in the temperature, or the difference between the temperature of the air at the exit of the hot side to the entrance of the energy separator, versus the pressure ratio on the hot side. Fig.(2c) shows a graph of revolutions per minute (rotational sped of the rotors) versus the amount of air passing through the model. Finally, a separate graph, Fig.(2d) shows the relation between the flow rate versus the total difference in the temperatures of hot and cold sides. While working at a pressure ratio of 1.2 and 15,000 rpm, the temperature difference between hot and cold sides has been observed to equal to 64 degrees F. The cooling and heating capacities of the device under these conditions are both 6170 BTU/hr. Using the experimental values of the rotational speeds of the mode at corresponding pressure ratios as a basis for the theoretical calculations, all of these experimental results have been compared with theory and as can be seen in these graphs. A very good compromise has been found between theoretical prediction and the experimental observations.

THE NEVER ENDING AGE OF ELECTRONICS .....

by Swati R. Patel, Thang Q. Le, and Thomas M. Kee

TODAY'S electronic world—boundless with its inventions and ominous in its research — has expanded like never before in its progression of electronic devices. This rapid advancement in electronics technology however, is greatly dependent on science. Electronics supports the idea that science invents and technology develops and manufactures.

One area of electronics that has always been of abundant interest is semiconductor technology. Early semiconductor theory was based upon the working principles of the vacuum tube. The progression of the vacuum tube expanded from the simple vacuum diode to the vacuum triode. With the addition of various grids, further advancements arose, such as the vacuum tetrode and the vacuum pentode. Though this crude electronic device served its purpose as a current regulator, it had many drawbacks. The early vacuum tube was bulky and fragile, consumed a lot of power, had a restricted life which resulted in limited reliability, and required a fairly high operating voltage. Also, the time needed to heat up the vacuum tube's inner filament minimized its operation readiness. Such restraints were especially troublesome for portable devices (e.g. radios and walkie-talkies); therefore, new innovative ideas were being investigated.

On December 23, 1947 in Murry Hill, New Jersey, what some called the "major invention of the century" occurred at Bell Laboratories. The transistor, a device which uses semiconductor material to amplify an electrical signal, was discovered. Some of the motivation to invent the transistor was prompted by the desire to find a device better than the vacuum tube; however, the greatest consideration was avid interest in miniaturization of existing electronics.

Even though the transistor later proved to be a more preferable device, there were many skeptics during this time due to its insufficient reliability. For example, it was noisier, could only handle limited power, was restricted in frequency performance, and was more susceptible to damage by power surges, radiation and high temperatures. Due to these limitations, designing a transistor which gave an approximation of its required individual characteristics, was very difficult. Furthermore, producing two transistors with the same characteristics was nearly impossible.

Advancements in transistor technology was initially not widely accepted, since so much effort had been devoted in the past to the development of vacuum tube theory and because so many early transistor problems had existed. When these initial obstacles were overcome, the transistor proved to be better than the vacuum tube because of its less power dissipation, smaller size, lower cost, better efficiency, and fast turn-on time (virtually instantaneous), since there was no filament to heat.

The transistor's implementation has had an impact

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As electronics progressed, miniaturization was emphasized . . . . as seen by the decreasing size of these three devices: magnetron(top), vacuum tubes(center), and transistor to IC(bottom).

in virtually all areas of electronics. Much effort has been devoted since that time in eliminating the transients that were created in the electronics world from the introduction of such a revolutionary device. After discovering its individual characteristics, the development of methods suitable for the use of transistors was the next great effort. Most importantly, this research and development has led to the miniaturization of electrical circuits and its components, better known as integrated circuits or IC's - an endeavor unimaginable in the past, yet a mere stepping stone for the ever-expanding future world of electronics.

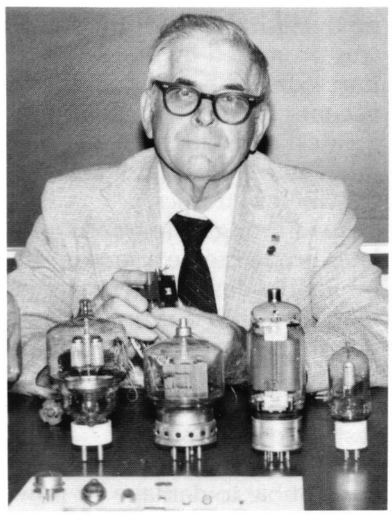
To elaborate on these two devices, experts in the electronics field were interviewed:

VACUUM TUBES ... Interview with Derrill C. Rohlfs

Q — Explain the progression of the vacuum diode to multiple grid vacuum tubes.
A — The vacuum diode, its birth appearing in an Edison experiment on light bulbs in 1883 later called the Fleming valve, had current flowing in only one direction; however, this current needed to be controlled. Thus, in 1907 a controller grid was placed between the cathode (which emits the electrons) and the positive anode plate by DeForest. The addition of this grid enabled the current to be controlled, and in so doing, developed the vacuum triode.

With this development, however, oscillations or instabilities were a result. A second grid called the screen grid eliminated these oscillations, thus leading to the development of the tetrode vacuum tube. Negative resistance, however, was a setback in this new tetrode vacuum tube. With the addition of the suppressor grid, this negative resistance and other instabilities (produced due to certain operating conditions) were overcome to finally create the pentode vacuum tube.

Higher gain and amplification was achieved with each additional grid being utilized. Furthermore, the power-handling capabilities were accomplished by means of increasing the size of the vacuum tube. The final result of this progression was the development of multiple grid vacuum tubes, being manufactured in various sizes.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Derrill C. Rohlfs is an Associate Professor and Director of the GWU Electronics Laboratories who received his undergraduate and graduate Electrical Engineering degrees at George Washington University. He worked for the Naval Research Laboratory, where he has received many honors and has written numerous papers relevant to Communication and Radar Systems. During his employment with NRL, he was also a part time EE instructor at GWU. Over the years, he has acquired interests in all fields of electronics, specializing in high power radars, circuits and communications. After being a full time instructor at GWU for the past 7 years, he says that teaching is most important to him and he would not trade it for anything. His teaching endeavors have resulted in his receiving the full time "Instructor of the Year Award" for 1985-86, honored by Eta Kappa Nu.

Q — What was the vacuum tube's main initial purpose?
A — Its purpose was to create a means of controlling current flow; thus, attaining higher amplification of current and voltage or better stated as, "attaining higher gain for the device".

Q — Explain the working mechanism of vacuum tubes.
A — The cathode, a cylinder constructed of tungsten material, emits the electrons. It can be directly heated or indirectly heated. If the latter is true, then inside the cathode cylinder is a filament that heats up just like an incandescent light bulb. The heat from this filament heats up the cathode, thus enabling the cathode to emit the electrons.

When a positive voltage is applied to the anode (plate), electrons are attracted to it. The negative terminal of the voltage is connected to the cathode. Thus, a diode is formed. The grid and screen give better control over the electron flow. The screen or tetrode grid eliminates some oscillations in the device due to different operating conditions. Since the current flow can be directed better towards the anode plate with the grid and screen, higher gain of the device is attained.

Q — How long is the working life for an average vacuum tube?
A — The working life is dependent mainly on the cathode deterioration and burning out of the filament. This cathode breakdown occurs when, over a period of time, the voltage has stripped away too many electrons from the cathode. Then, replacement of the cathode is necessary. To increase the working life of the filament, higher voltage is applied to the filament or heater for a short period of time.

Q — What were some vacuum tube applications in the past and what are they now?
A — In the past, "AUDIONS" (known as 201's) or vacuum triodes were used in most everything. For example, antique

radio sets used these early vacuum tubes as RF amplifiers, detectors, and audio amplifiers.

Vacuum Tubes are still in demand today in radio communications and broadcasting systems. More specific applications include: computer screens, television picture tubes, magnetrons in radar systems, power tubes as used in radio-broadcasting systems, and FM radio systems.

In a closing statement Professor Derrill C. Rohlfs concluded our interview to claim, "State of the art solid state has not yet replaced high power vacuum tubes."

TRANSISTORS ... Interview with Nevine El-Leithy

Q — What was the transistor's main initial purpose?
A — A transistor was initially developed to replace the vacuum tube in amplification capabilities. It was invented specifically for the amplification of signals and switching on and off instead of using relay systems in communications.

Q — What is the description and basic working principle of the bipolar junction transistor (BJT)?
A — A BJT consists of a silicon (or germanium) crystal in which a p-layer is sandwiched between two n-layers, or an n-layer is sandwiched between two p-layers. The first type is an npn transistor and the latter is a pnp type. The three regions of a transistor are called the emitter (E), base (B), and collector (C). Figure 1 shows the two types of BJT transistors and Figure 2 shows them when they are used as circuit elements. The arrow on the emitter shows the direction of current when we forward bias the emitter junction. Typically the arrow points inwards for a pnp transistor and outwards for an npn transistor. When the currents flows into the transistor, they

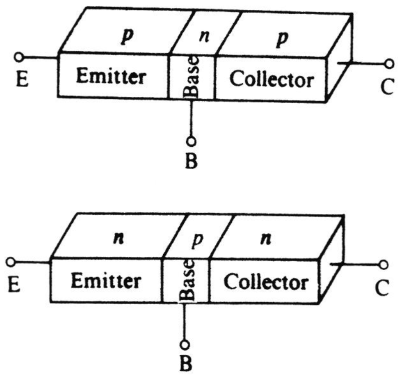


Figure 1. Two types of Junction Transistors, PNP and NPN respectively, shown in block-like illustrations.

are considered positive currents. Symbols like V(EB), V(CB), V(CE) represent emitter-base, collector base and collector emitter voltages respectively.

The transistor has three modes of operation: cutoff, active, and saturation. When operating like a switch, the transistor works in the cutoff and saturation modes (it is either on or off). The transistor operates as an amplifier in the active mode. Whether the transistor is a current amplifier or a voltage amplifier, in the active mode of operation, the current or voltage will be amplified, respectively. These three modes of operation depend on the base current and the emitter to base voltage. Let us now look at the basic working mechanism of the transistor with and without external biasing.

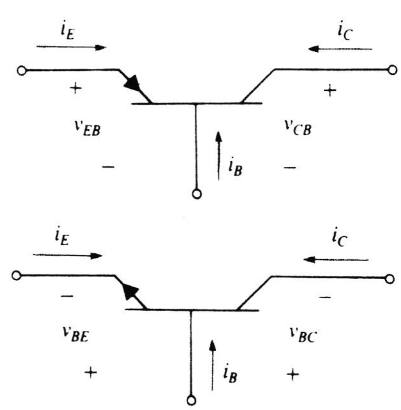


Figure 2. PNP and NPN transistors shown as circuit elements.

The Open Circuit Transistor —

With no external voltages, all transistor currents must be zero. The potential barrier at both the junctions (the base emitter junction and base collector junction) will be at V(o), the contact potential value. At this stage the barrier height is identical at both the emitter and collector junctions. Under open circuit conditions, the minority concentrations are at their thermal equilibrium values in all the three regions.

Transistor Biased in the Active Region —

Now consider the actual working of the transistor when it is used as an active element. We do this by considering a pnp transistor (similar concepts apply for an npn too). For the transistor to be biased to work in the active mode of operation, the emitter base junction is forward biased and the collector base junction is reversed. The externally applied voltages appear essentially across the junctions. If V(EB) is emitter base voltage (which is forward biased) and V(CB) is collector base voltage (which is reversed), the potential barrier at the emitter base junction is reduced by V(EB) and at the collector base junction is increased by V(CB).

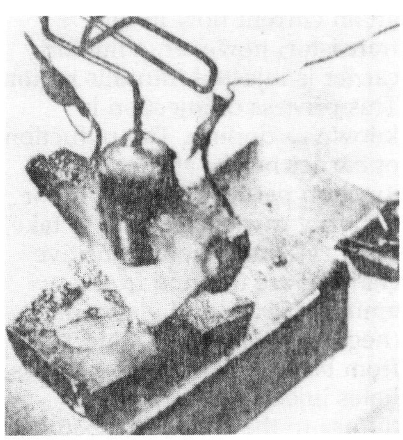
When a region consists of a certain type of charge, it is known to contain majority carriers. To attain current flow in the transistor, however, a minority carrier is injected into this region. This process of injection is known as doping. The reduction of barrier height at the emitter junction permits this doping or minority carrier injection to take place, in which holes (positive charges) are injected from emitter to base and electrons, (negative charges) are injected from base to emitter. The excess holes injected into the base diffuse to the collector junction, because the electric field intensity is zero in the base. At J(c), the collector base junction, the field is large and positive. As a result, the holes are accelerated

across this junction. In short, holes that reach J(c) fall down the potential barrier and are collected by the collector.

If I(E) is the total emitter current (consisting mainly of holes), not all of this current that is injected into the base reaches the collector. Some of the holes are lost due to recombination (joining of holes and electrons) in the base. So, only a fraction of the emitter current reaches the collector junction. This fraction is called alpha. These are the fundamental principles on which the operation of the transistor is based on.

Q — What is the progression from early transistors to today's transistors?

A — Earliest transistors were point-contact transistors (invented by Drs. John Bardeen and Walter H. Brattain of Bell Labs.) which consisted of a germanium crystal connected to two gold wires. A current was injected at one point was received at the other point with amplification. However, these types had very low gain, bad frequency response, and were inefficient to manufacture. So the idea of varying the doping density and getting an npn or pnp transistor came about. By diffusing certain impurity compounds into the semiconductor, the doping can be varied to get a p-type or n-type semiconductor.



The first transistor consisting of two wires, located only a few thousandths of an inch apart, with their ends touching a wafer of germanium.

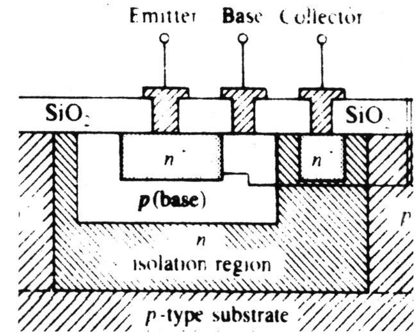
The first types of npn or pnp transistors, known as junction transistors (first invented by Dr. William Shockley) were discrete alloy types. Then the planar process was developed, in which an epitaxial layer is grown on a monolithic (single layer) substrate and n-type or p-type diffusions are made into that epitaxial layer. This led to the well established IC technology.

In summary: (1) point contact transistors came first (2) pnp and npn discrete junction transistors came next and (3) planar process for pnp and npn transistors is now being utilized most in the IC industry.

Q — What problems were encountered during the transition of early transistors to today's transistors?

A — Three main problems:
(1) controlling the doping of a compound into a semiconductor
(2) growing a perfect silicon crystal lattice (silicon crystals, like other crystals form a grid like lattice shape, in which the entire structure appears to be small cubes attached together by bonds) with zero imperfections in the structure
(3) metal to semiconductor contact problems - the three leads to which the emitter, base, and collector are attached are metal wires, made of aluminum or copper. When a metal is in contact with a semiconductor, we can obtain either an ohmic or rectifying contact (current capable of flowing in both directions across the metal semiconductor junction) depending on the degree of doping in the semiconductor.

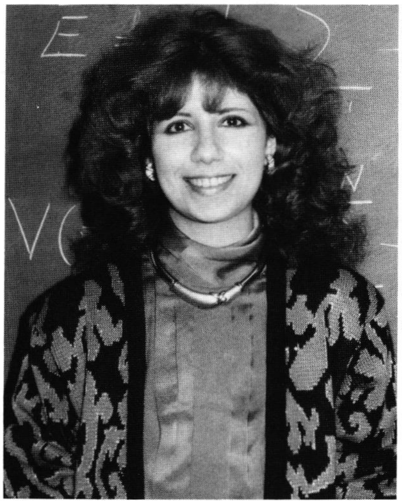
Research and development in the area of solid-state electronics resulted in minimizing many of these problems as witnessed by the impact of IC technology on most aspects of our lives. Our improved understanding of the physics of devices has led to the VLSI (Very Large Scale Integration) revolution. Devices are now smaller and faster approaching the submicron scale and the pico or even femto second range. VLSI is expected to reach its limit of integration in the 1990's.



The planar process is illustrated above by a single npn BJT, utilized in an IC chip.

Q — What were some transistor applications in the past, and how have they evolved to include IC applications?

A — They were used earlier as discrete transistors, in which each circuit containing a transistor had to be manually constructed. Radios, developing computers, televisions and telecommunication systems were some applications for transistors in the past. During this time, the transistor was being used to amplify in a solid state form. But once the discovery was made that it also operates in the saturation and cutoff modes, digital technology was discovered and the computer industry was saved. Today's uses of the transistor not only include applications of the past, but go further to encompass endless applications of integrated circuits (IC's), such as, medical equipment, power systems, industrial systems, information systems, robotics, and factory machinery (which operates on microprocessors). Technically speaking, uses of IC systems (digital and analog) include digital and analog computers, voltage-to-current and current-to-voltage converters, direct current (DC) instrumentation amplifiers, voltage followers, active filters, precision ac/dc converters, peak detectors, sample-and-hold systems, analog multiplexers and multipliers, logarithmic amplifiers, and lastly, A/D and D/A converters.



BUDIJANTO W. TJAHAJADI

Nevine El-Leithy is a graduate teaching assistant for Electrical Engineering at GWU received her Bachelors degree from Cairo University, Cairo, Egypt in 1984, her Masters degree in Electrical Engineering from George Washington University, and is currently working at GWU on her Doctorate degree in Microelectronics. Some of her experience as an Electronics Engineer includes working for Siemens Company in Munich, Germany, and for Aptec (Appropriate Technology Inc.) Inc. in London, England. She is also a member of the Research Faculty at University of Maryland. Aside from being a guest editor for CIRCUITS AND SYSTEMS TRANSACTIONS published by IEEE, a reviewer for several other journals, and a member of the Robotics and Automation Committee of the Circuits and Systems Society, she has several publications in circuits & systems design and neural networks, and has given many conference presentations around the world. Although her interests include all fields of electronics, she specializes in neural networks, III-V Semiconductor Compounds, mainly gallium arsenide, and Advanced Analog Design Concepts. It's no wonder that she was honored the "GTA of the Year Award" for 1985-86 by Eta Kappa Nu.

• • •

Q — What is the next step in the progression of transistor technology?

A — "The trend now is to find new concepts in design. Our approaches are still influenced by the design ethics that still survive from the era of discrete device electronics involving the assumption that a system is a network of discretely interconnected devices and can only communicate via the similarly isolated interconnected network." She goes on to say that one promising direction is the use of III-V semiconductor compounds, for example, gallium arsenide as it offers a wide range of possibilities that need to be exploited. In particular, current fabrication techniques allow the formation of 'HETEROSTRUCTURES' where materials can be tailored to achieve certain electronic properties that have not been investigated before and may pave the way to building adaptive computer architectures. Moreover, there is the possibility that the interconnection problem encountered in ULSI (Ultra Large Scale Integration) could be overcome.

In her closing remark, Miss Nevine El-Leithy states, "The Oxford Dictionary defines the word revolution as 'a fundamental reconstruction'.... the discovery of the transistor came at exactly the right time to rescue the infant computer science from the disasters brought about by the inefficiency of the vacuum tube ..... the invention of the transistor was and still is a fundamental reconstruction, which has changed all facets of our lives."

At this time, the MECHELECIV writing staff would like to thank all the instructors who spared time from their busy schedules to help in creating this article. Deepest appreciation goes out to Professor Derrill Rohlfs and Miss Nevine El-Leithy.

• • •

Swati R. Patel is a senior CO-OP Electrical Engineering student working for the Tactical Electronics Warfare Division at Naval Research Laboratory. Aside from maintaining her academic interests, she enjoys being a staff writer for MECHELECIV and being a member of the IEEE Engineering in Medicine and Biology Society. She also aims to further her studies towards receiving a Masters Degree in Bio-Medical Engineering.

•

Thang Q. Le is a senior in electrical engineering. He works for the National Institute on Aging in the Epidemiology Demography and Biometry Program. He is also an active member of Tau Beta Pi, Eta Kappa Nu, and IEEE. His goal while attending GWU is to help in the creation of an influential learning institution. He would like to attain a Master's Degree after a short break from college life.

•

Thomas M. Kee is a senior majoring in Electrical Engineering. During semester breaks, he works at the Naval Security Station as an engineering aide in the Cryptologic Engineering Division. His job takes him to various parts of the world , such as RAF Chicksands. He is also a standing member of IEEE. When he graduates in 1988, he would like to pursue interests in the communications field as an electronics engineer.

EULER UY

Spanning Over Time . . .

by Poh Chuan Chua

As machines save more labor, multiply power,and increase mobility; bridges are built longer, safer, and more fanciful. Two major concerns in bridge constructions are the type of structures to be chosen and the material to be used. Although one may recognize many different types of bridges, but there are only three basic types: beam, arch, and suspension cable. Combinations and variations of the these basic types are possible.

The first basic type of bridges is based on beams. Beams neither thrust nor pull, they rest on their supports or abutments. The load is transmitted vertically to the supports; therefore, gravity is the only force involved. Beam tends to break at the middle of its span. It requires material that is strong both in tension and in compression since the the top part of the beam is always squeezed while the bottom part is always being pulled. A beam type bridge can be as simple as a timber log resting on the two banks of a river.

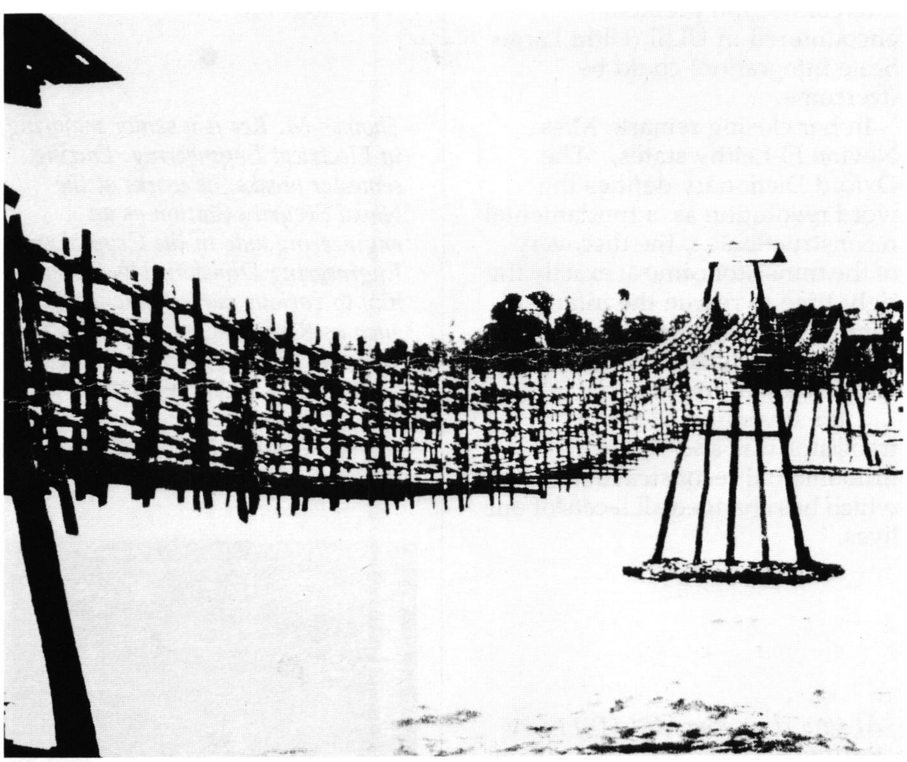
On the other hand, arches are constantly compressed. Abutments for arches are made strong in order to support the powerful thrust exerted by the arches. Stone and concrete are probably the best materials for arch constructions, since they are strong enough to handle compressive loading. Some types of arches used in bridge building are fixed arch, two-hinged arch, and three-hinged arch.

The third basic type of bridges is based on suspension cables. Suspension cables pull their abutments and are always in tension. The cables are usually composed of a material that is not only flexible but is also strong in tension. Twisted vines, metal chains, ropes, and steel wires are frequently used. Suspension bridges are usually long with some even spanning over four thousand feet.

Choosing the right material does not only depend on what kind of bridge to be built but also depends on it availability, cost, and strength. Stone, wood, iron, steel, and reinforced concrete are the most common materials for bridge constructions. Each of these materials had its own glory days in bridges building history.

Stone is believed to be the oldest material used in bridge construction. The Romans were the greatest stone arch builders. Due to the natural life of stone, and the fact that stone bridges require little or no maintenance, many ancient stone bridges are still standing. Stone is the ideal material for arch constructions because it can withstand high compressive loading. In the recent years, stone has become undesirable because it is not only expensive but it also takes time to be quarried, dressed, and individually fitted.

Wood is a material that is strong both in tension and in compression. It was used extensively by the Americans for railroad bridges after the Revolution. It was cheap, plentiful, and could be dealt with relatively easier than stone. Since wood can only be worked as separate pieces, it is not surprising that truss has its early development in wood. A great disadvantage is that wood has a short matural life of twenty to thirty years and suffers damages



The Wooden Suspension Bridge over the Min River, Szechuan, China stretches the total length of 1800 feet.

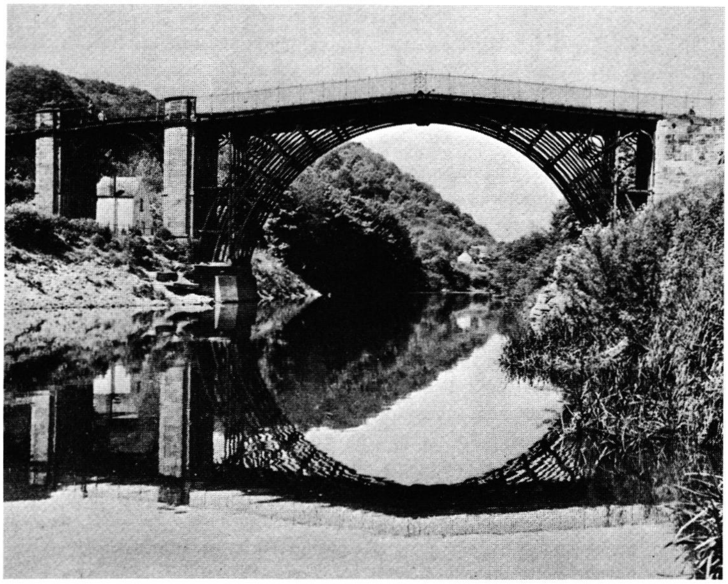
from flood and fire. As a result, there aren't many wooden bridges alive today.

When an economical method of smelting iron in large quantities was discovered, iron became the material of the Industrial Revolution. More iron bridges were built when the Iron Bridge by Abraham Darby III turned out to be the only survivor from the 1795 Severn River Flood. Iron is not only stronger than wood but also more durable; nevertheless, it became less revolutionary when Henry Bessemer patented a process for making steel cheaply and in large quantity in 1856.

The Eads Bridge in St. Louis is the earliest major steel structure. It was completed in 1874. Since then, more and more steel bridges were constructed. Among others, the Forth Bridge in Scotland, the Hell Gate Bridge in New York, and the Golden Gate Bridge in San Francisco are some good examples. Due to its high strength and durability, steel is still being used extensively. As long as there are no other metals that can provide higher strength at a low cost, steel will continue to be the dominating metal in structural construction.

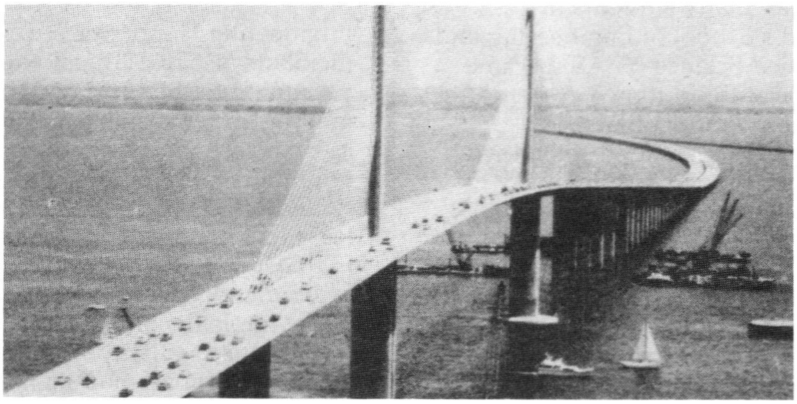
Eventually, concrete became more important when the concept of reinforcement was introduced. Concrete itself is only strong in compression and brittle against bending. Embedded reinforcing steel bars provide high resistance against tensile loading. Today, reinforced concrete is the material of the twentieth century. It is very strong, non-corrossive, and relatively cheaper than steel. It can be poured into any kind of geometrical shape as long as the form work is possible. Creative and artistic designs of Robert Maillart's bridges are derived from this important characteristic of reinforced concrete. Modern concrete technology allows concrete to be precasted into segmental pieces. This is an important breakthrough because difficult job site construction can be reduced to a relatively easier segmental assembly.

The need of more bridges in the future is obvious. Modern bridge designs are based on the three important factors of safety, economy, and beauty. More and more types of bridges will be derived from those three basic types and stronger, cheaper material will to be explored in order to meet these modern design criteria.



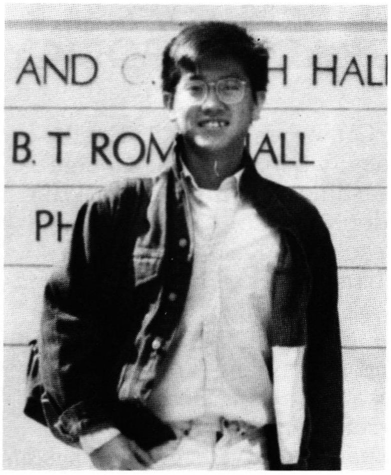
J. Wayman Williams

The iron bridge of Severn River, Coalbrookdale, England is the first major structure ever built of iron.



ASCE

The Sunshine Skyway Bridge over Tampa Bay, Florida, USA is the longest precasted concrete segmented bridge in the world.



BUDIJANTO W. TJAHAJADI

Poh Chuan Chua is a senior scholar from Malaysia, majoring in CE. In addition to his scholastic achievements, Poh is involved in other activities. He is president of Tau Beta Pi, the senior representative to the Engineer's Council, and is an active member of the ASCE. Poh worked for 7K Construction Company during the summer and will also be participating in the honors research program.

GREETINGS FROM ENGINEER ALUMNI ASSOCIATION PRESIDENT NAHID KHOZEIMEH

On behalf of the Engineer Alumni Association, I would like to take this opportunity to welcome all returning and new students to the GW Campus for another academic year. Since many of you might not be aware of the EAA existence and its activities, I will briefly describe the EAA.

The Engineer Alumni Association started over 40 years ago by a number of interested alumni, who volunteered to work on matters of mutual interest as an independent organization from the University and their School of Engineering (now SEAS). Since then, our organization has grown and become active in affairs concerning the Alumni and the student body. The membership is now automatic (i.e. as soon as you graduate and receive a degree, you are automatically considered an Alumni.) There are no association dues per se. A representative from the Engineer's Council attends our monthly meeting and keeps us up-to-date on the Council's various activities.

EULER UY

The EAA conducts many technical and social programs to satisfy varied interests. These events include the joint alumni/student fall picnic, the Distinguished Frank Howard Lecture Programs, annual alumni award/Dean's reception, the jointly published MECHELECIV magazine, and many others.

We, at the EAA, would like to be aware of your specific needs in order that we may lend a hand or provide guidance whenever possible. You may reach us via the Engineer Alumni Association Alumni House 714 21st Street, N.W. Washington, D.C. 20052.

Best regards and success in the coming year.

PLUS/MINUS GRADING POLICY

On March 13, 1987, The Faculty Senate of The George Washington University (GWU) adopted Resolution 86/9, "A Resolution Recommending Changes in the University's Grading System," as proposed by its Committee on Educational and Admissions Policy. The resolution consisted of three recommendations. Firstly, it expanded GWU's grading system to include pluses and minuses along with the current letter grades. Secondly, the numerical equivalents for determining the quality point index (QPI) or grade point average (GPA) were assigned the following values: A = 4.0, A- = 3.7, B+ = 3.3, B = 3.0, B- = 2.7, C+ = 2.3, C = 2.0, C- = 1.7, D+ = 1.3, D = 1.0, and D- = 0.7. Finally, Resolution 86/9 also called for this plus/minus grading policy to be implemented starting with the fall 1987 semester not retroactively and for the appropriate notations to be included on student transcripts.

Although reports pertaining to the plus/minus grading policy appeared in The GW Hatchet prior to its adoption by The Faculty Senate, many students of GWU's School of Engineering and Applied Science (SEAS) became aware of Resolution 86/9 only after its adoption. Soon after, engineering students expressed opinions ranging from ones characterized by apathy to shock to dismay to condemnation.

On April 2, 1987 at a regular meeting of GWU's chapter of Eta Kappa Nu, the International Honor Society for Electrical and Computer Engineers, members by an overwhelming majority passed a motion disapproving the plus/minus grading scale. The prevailing sentiment was concern regarding the lack of student input and official notification to students that such a major revision in the manner in which instructors evaluate students was under consideration.

On April 15, 1987 at a regular meeting of GWU's chapter of Tau Beta Pi, the National Engineering Honor Society, members also exchanged views pertaining to the plus/minus grading system. The consensus arising from their discussion was to draft a letter addressed to Dr. Roderick S. French, GWU's Vice President for Academic Affairs. In that letter, Tau Beta Pi members recommended a postponement in the implementation of the plus/minus grading policy until furthur examination of its merits and suggested changes to the policy as it is stated in Resolution

86/9. Among the suggestions included the addition of an A+ with a numerical equivalent of 4.3, the attachment of a grandfather clause so that the grading policy would be implemented starting with only the next class of incoming freshmen.

On May 5, 1987, in response to the concerns of students, SEAS invited student representatives to express the views of engineering students at a special SEAS faculty meeting. The coalition of student representatives consisted Mr. Carmen J. Kocinski, chairman of GWU's chapter of The Institute of Electrical and Electronics Engineers (IEEE), Mr. Ka P. Lee, president of GWU's chapter of Eta Kappa Nu, Mr. Hassan Ibrahim, president of GWU's Engineers' Council, and Mr. Louis R. (Bob) du Treil, Jr., member of Tau Beta Pi, IEEE, Eta Kappa Nu, and the Engineers' Council. Mr. Kocinski began the presentation by inquiring as to the purpose for changing the grading system. "Engineers don't bother the fix what isn't broken," Mr. Kocinski stated. Mr. Lee read the Tau Beta Pi letter addressed to GWU's Vice President for Academic Affairs. The coalition proceeded to discuss questions that students have mentioned concerning the plus/minus system. Among such questions were how thoroughly did The Faculty Senate investigate the impact of a similar plus/minus system at other universities, what are the views of employers concerning how students are graded, what are the view and recommendations of the Accreditation Board for Engineering and Technology (ABET) on grading systems, why not include an A+ into the grading scale, what are the benefits of and who will benefit from the plus/minus system, and does GWU want to emphasize grades over learning. Professor Raymond R. Fox, chairman of the Civil, Mechanical and Environmental Engineering (CMEE) Department and a member of The Faculty Senate, replied that The faculty Senate did conduct an investigation into the plus/minus system. EE/CS Professor Raymond L. Pickholtz mentioned that the SEAS faculty would be interested in examining the results of such an investigation. Associate Dean James E. Feir recommended that a grandfather clause should be considered if the plus/minus grading scale is implemented so as not to disrupt the students midstream in their curriculum. As for ABET, Mr. Kocinski announced that he was able to contact Mr. Peter Smith with ABET in New York and learned that ABET has no criteria for grading systems. After a further exchange of questions and answers between the SEAS faculty and the student coalition, the student representatives departed and the professors discussed the matter of the plus/minus system among themselves. However, the necessary quorum was not present in order for the SEAS faculty to pass any motions.

A subsequent SEAS faculty meeting was held on the following week. At that meeting, with the necessary quorum of professors present, the SEAS faculty passed a resolution stating that they have no strong objection to the plus/minus system, but request that The Faculty Senate state the reason for wanting a change in the grading policy and provide the relevant data supporting such a change.

A temporary ruling on the plus/minus system was not made until the start of the 1987-88 academic year. In September, the SEAS faculty arrived at a decision to defer the adoption of the plus/minus system until further review. However, the final word on the implementation of the plus/minus grading policy is still pending.

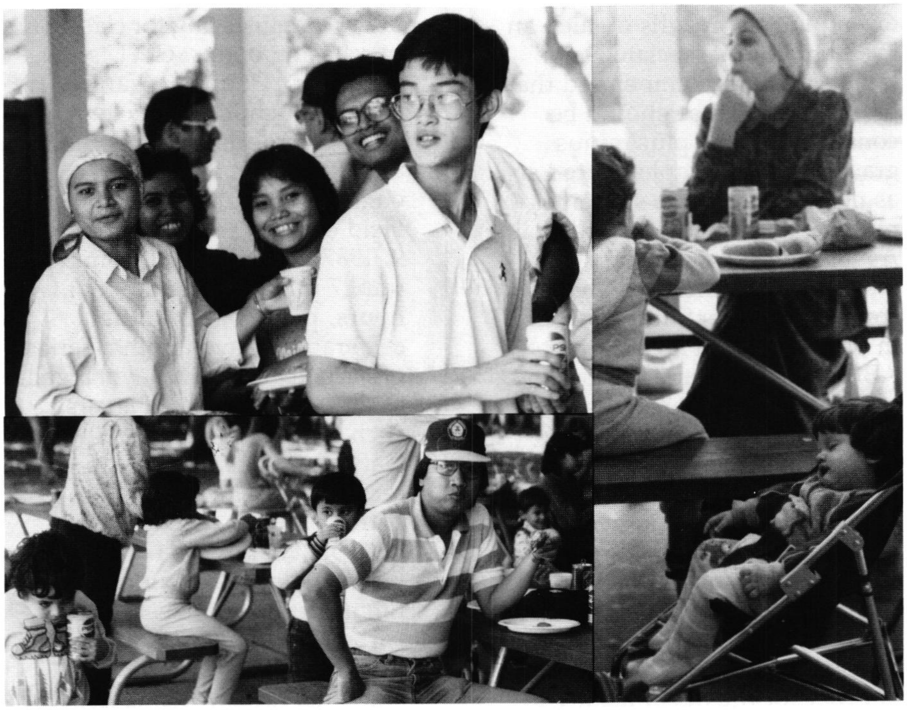
— *Ka P. Lee*

Better Than Nice was NAYC

After their arrival at GWU, SEAS students found a pleasant surprise while in the hectic midst of registering for classes and purchasing books. GWU's Engineers' Council organized a New Academic Year Celebration (NAYC, pronounced like the word "nice") for the enjoyment of all engineering students and faculty. Held on Wednesday, September 9, 1987, NAYC lasted from 3 p.m. until 7 p.m. During the first two hours, participants in the celebration played both a series of basketball and volleyball games at the Smith Center. Players such as George Fattal and Ali Nafee from the winning teams received Redskins mugs as a prize. A free barbecue occupied the latter half of NAYC. For nearly two hours, volunteers from the Engineers' Council served barbecued hamburgers and soft drinks while over a hundred students, faculty members, and staffers from Tompkins Hall mingled informally. At one point, when the supply of hamburger buns was dwindling, Council President Hassan Ibrahim and Secretary Ka Lee had to jog to a nearby grocery store to purchase more. In the end, all agreed that fun was had by many.

— *Ka P. Lee*

Good Food and Great Fun . . . at the Fall Engineer's Picnic



BUDIJANTO W. TJAHAJADI

Although the cold front hit DC early this year, Saturday, September 26, 1987 couldn't have been warmer for a friendly picnic. The Engineer Alumni Association got together with the Engineers' Council to hold their Annual Fall Picnic at Carderock, Maryland . . . "an ideal place filled with blue skies, green grass, and exhilerating scenery . . . everything that states a change from GW's concrete pavement!"

As the Engineers' Council and the Alumni Association provided free transportation, sports equipments, and All-American delicacies, the students, professors, and alumni offered their enthusiastic support and sportsmanlike spirit.

Brief conversations with those who attended allowed us to make the following observations:

1) The picnic gave GW's engineering community a relaxing day, one without work, pressure or tension. Many found that the picnic also provided them an opportunity to enjoy their weekend with their families.

2) It was a great time to socialize. Students were able to talk to their professors without any "classroom formalities" and also were able to make contacts with many of the alumni. As for the alumni, it was a good time for them to reunite with their old friends and to learn how their old college has improved over the years.

3) Carderock was an ideal place to have the picnic; it was spacious, clean, and within driving distance. Many attendees agreed that future picnics should be held at the same location.

4) Compared to last year's picnic, many improvements had been assessed this year. Food and drink supplies were increased, more sports equipment was provided, the shuttle bus service was more efficient, and most importantly, the number of participants had also increased significantly.

5) However, more efforts should be implemented in promoting the picnic. The organizer, alumni, faculty, and students should share the responsibility in publicizing it. The goal of the Fall Engineers' Picnic would not be entirely achieved unless more participation from everyone was involved.

The engineering community should give their maximum support to the picnic since it is the only annual gathering that would bring all the alumni, faculty, and students together to meet informally for a day of good fun and laughter. Hope to see everyone there next fall!!!!

— Poh Chuan Chua and Claire Silvestre

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Welcome Note from the President of the Engineer's Council

My Fellow Students:

I would like to welcome all new and returning students, and hope you have a successful year. Your council, the Engineers' Council, is the elected student governing body at the School of Engineering and Applied Science. Our function is to act as a liasion between the student body, faculty and administration, and the student government of the university, in all matters affecting your general interests and welfare.

I encourage you to participate in the events and activities the council has planned for you. These events include field trips, the Engineer's Olympics, a term paper contest, a Chess Championship, and last but definitly not least, the Engineer's Ball, which is becoming increasingly the "G.W. Ball".

Please stop by and visit your representatives at the Davis Hudgons House(2142 G Street) and make the best use of the facilities you paid for! Your comments and suggestions are greatly appreciated, so please stop by the D.H. House or call 994-8691 (9-5).

Sincerely,
Hassan Ibrahim
President of the Engineers' Council

ETA KAPPA NU REUNION

The Theta Iota Chapter of Eta Kappa Nu (HKN) is in the discussion stage of holding a reunion for recent GWU Eta Kappa Nu graduates. HKN graduated interested in assisting with organizing the reunion of in participating should contact Ka Lee at (202) 842-2547 in the evenings.

— *Ka P. Lee*

IEEE PLANS S-PAC FOR MARCH, 1988

At its most recent student meeting on September 9th, the Acting Chairman of the Student Branch, Carmen Kocinski announced ambitious plans for the IEEE to sponsor an S-PAC in March, 1988 here at GW. The S-PAC (Student Professional Awareness Conference) permits engineering students to learn from the wide-ranging experience of successful engineers. The S-PAC is sponsored by the IEEE, students from the other engineering disciplines will be encouraged to attend.

This coming semester the IEEE plans a variety of other exciting activities including a series of lectures in conjunction with the EE/CS department and a tour of the Naval Research Laboratory.

For those wishing to join the IEEE, now is the time Student rates are considerably lower than that of regular members. All members automatically receive the award-winning Spectrum magazine. Students may also join an IEEE Society at a discount rate of 25% off the regular cost.

— *Bob duTreil*

Continued from page 3

originally thought that something more massive than a planet such as a brown dwarf might be causing the perturbations. When nothing was found, Anderson decided on a planet with five times the mass of the Earth and with an enormously, eccentric orbit which is perpendicular to the other orbits in the solar system. It would revolve around the sun every 700 to 1000 years, retreating as far as 10 billion miles from the sun (double that of Pluto's 4.5 billion miles). So, when the Pioneers felt no gravitational pull, it may have been because the planet was too far away. When Uranus was discovered, Planet X may have been close enough to cause Uranus to wobble significantly.

Planet X may not be found for some time though, because astronomers do not know where to look. Also, the planet would be extremely dark and difficult to see. As Anderson says, "It could be found next week, but I wouldn't be surprised if it weren't found for the next hundred years."

— *Vaiji Ramaswami*

BUDIJANTO W. TJAHAJADI

On September 22, 1987, the president of the Engineers' Council, Mr. Hassan Ibrahim, and the president of Tau Beta Pi, Poh Chuan Chua, presented a trophy to the EE/CS department chairman, Dr. Lang. During the first Annual Engineers' Olympics, on April 17, 1987, the EE students were the overall winner of the events.

FOR YOUR INFORMATION

MECHELECIV encourages all students, alumni, faculty and staff of the School, and our other readers to contribute to or join the magazine and avail of this unique opportunity for organizational, journalistic and artistic experience, as well as receive exposure and recognition.
For more information, please call (202) 676-3998 or write to MECHELECIV.

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